Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/793
INDIA
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

PRIMARY COOLING WATER SYSTEM CHARACTERISTICS UNDER TRANSIENT CONDITIONS IN CIR

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The primary cooling water system of CIR is designed for recirculation with a normal flow rate of 4200 IGPM. Any shut down of the primary pumps results in a reactor scram, whereby recirculation is converted to a one-pass gravity feed emergency system with a flow rate of 1200 IGPM achieved in 8 seconds. The transition period between normal recirculation and full emergency flow condition is most important in hazards evaluation since during this period the flow and power coast down should be ensured to provide sufficient cooling to prevent fuel failure.

During commissioning period, a number of tests were conducted to determine system flow and pressure behaviour in the change-over period from normal recirculation to a one-pass system. The experimental flow coast down data were in general agreement with the predicted hydrodynamic characteristics of the system, though flow and pressure oscillations were observed. A computer programme was detailed to calculate the aluminium cladding and bulk coolant temperatures (in the change-over period) along the length of fuel rod, using theoretical flow coast down and power decay data. The computer was also programmed to estimate coolant saturation temperatures and to detect any boiling under the conditions. When the flow and pressure oscillations that were observed in the commissioning tests were super-imposed on the computer results, the uncertainty was so great that unsafe conditions of nucleate and/or bulk boiling appeared possible. Pending further investigations,

reactor power was limited to 30 MW and the rod output to 300 kW.

Several modifications to the cooling system for improved flow rates and pressures during change-over period were considered. Flow coast down tests were repeated to assess reproducibility of earlier results. At the same time, experimental measurements of coolant temperature transients at fuel rod exit were made under intermediate reactor power operating conditions to assess accuracy of computer predictions. No pressure and flow oscillations were observed during these and subsequent flow coast down tests. Observed temperatures being consistently much lower than predicted values, it was clear that there was no risk of the aluminium cladding of the fuel rod melting or the phase transition temperature for uranium being reached. Nevertheless, the observed temperatures indicated nucleate boiling for 40 MW operation. It was thus concluded that reactor operation at 40 MW called for certain modifications to the primary cooling system. Improvement in the hydrodynamic characteristics of the system was effected by installing fly-wheels on each of the primary coolant pumps, and flow coast down tests repeated. A computer programme with this data indicated the absence of boiling of any kind in fuel rods for a reactor power with individual fuel rod output not exceeding 330 kW. Only slight nucleate boiling was observed at fuel rod outputs of 375 kW. Further experimental measurements of temperature transients for cladding and exit water indicated little or no rise from normal equilibrium values for fuel rods under high power operating conditions, during the change-over period following pump shut down. As experimental values and computer analysis firmly established that there were no hazards involved in operating the reactor at high power, the reactor power was raised to the full design value of 40 MW and operated satisfactorily.